

# Air-Flow Simulation in Realistic Models of the Trachea

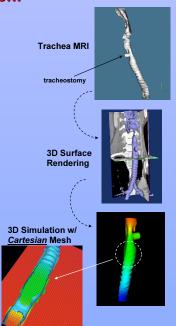


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#### **Motivation:**

- Computational fluid dynamics (CFD) simulations of complex flows in airways can provide clinicians with information on development of pathologies and treatment of disease
- Accurate methods are needed to extract surface models from CT or MRI data and to simulate flows in these models
- Current surface extraction methods lose detail when meshed for CFD simulations
- Via Cartesian grids we have developed an end-to-end technique--from surface extraction to meshing to CFD-that is fast and true to anatomical detail



#### **Methods:**

#### **Surface Extraction**

 Fast-Marching and Level-Set Methods are techniques which follow evolution of contours and surfaces and are particularly useful for shape recovery of complex anatomical geometries

#### **CFD**

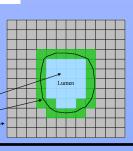
 We have developed a high-resolution code to solve the incompressible Navier-Stokes equations on Cartesian grids

$$\rho \frac{\partial \mathbf{u}}{\partial t} + \rho (\mathbf{u} \cdot \nabla) \mathbf{u} + \nabla p = \mu \Delta \mathbf{u}$$
 
$$\nabla \cdot \mathbf{u} = 0$$

## **Embedded Boundary Cartesian Grids**

 A high-order treatment of irregular geometries where the boundary cuts the regular cells and special stencils are used near the boundary

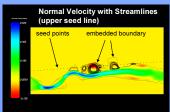
Rectangular Grid Cell
Embedded Boundary
Cartesian Grid

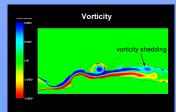


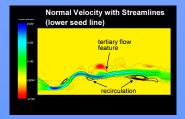
#### **Results:**

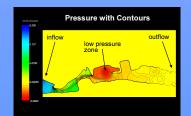
#### 2D simulation of air-flow in a trachea with tracheostomy

- Flow features due to irregular geometry are highly resolved
- Accurate 2D geometry obtained from slice of MRI image









# **Applications:**

## Cardio-Vascular Dynamics

- Stent design with drug delivery (molecular migration/interaction)
- Post-stenosis emboli dynamics (projectile-migration-blockage)

